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# NOZZLE ARRANGEMENT AND METHOD FOR PROCESSING A MATERIAL FOR PROOCESSING WITH A PROCESSING MEDIUM

The present invention relates to a nozzle arrangement and a method for the treatment of a treated material with a treatment medium. In particular, the present invention relates to a surge nozzle arrangement, which can be used, for example, in run-through systems for the wet chemical treatment of very thin printed circuit films or printed circuit boards.

Nozzle arrangements in the form of surge nozzles are used, for example, in run-through systems for the wet chemical treatment of printed circuit boards in order to achieve the fastest and most uniform possible treatment of a treated material in the form of printed circuit boards or printed circuit films running through the systems. In this situation, it is usual to have several surge nozzles arranged above and/or below a run-through plane of the treated material, so that the nozzle arrangement extends transverse to the direction of conveying of the treated material essentially over its entire width. With the surge nozzles, a treatment fluid is sprayed onto the surface of the treated material or sucked up from it, in order thereby to achieve a constant and uniform exchange of the treatment fluid on the surface of the treated material.

In EP 1 187 515 A2 a large number of different nozzle arrangements are proposed in this respect. In this situation, in each case essentially circular pipes are used, which have different nozzle shapes. These nozzle shapes can be, for example, slot nozzles arranged obliquely, circular nozzles arranged next to one another in a large number of rows, or slot nozzles with different widths running in rows next to one another. The nozzle arrangements described relate in particular to pivot nozzles, with which a periodic change of direction of a fluid flow of the treatment fluid can be achieved while the treated material is running past.

In DE 37 08 529 A1 the use of slot nozzles is proposed, whereby, thanks to a variable slot width of the corresponding nozzle, the flow volume and spray

pressure of the individual treatment fluid can be adjusted.

In DE 35 28 575 A1 a nozzle is used for the cleaning, activation, and/or metallisation of drillholes in printed circuit boards running horizontally, said nozzle being arranged beneath the conveying plane and perpendicular to the direction of conveying, from which a fluid treatment medium in the form of a standing wave is delivered onto the underside of the individual printed circuit board running through the system. The nozzle is arranged in the upper part of a nozzle housing, which is formed by a preliminary chamber with an intake aperture, whereby the preliminary chamber is separated by means of a hole mask from an upper part of an inner space of the nozzle. By means of the hole mask, a distribution of the flow of the fluid treatment medium towards the nozzle is achieved. The inner space of the nozzle in front of an actual nozzle aperture in the form of a slot serves as a preliminary chamber for a uniform build-up of the surge of the fluid treatment medium.

From EP 0 280 078 B1 a nozzle arrangement is known for the cleaning or chemical treatment of workpieces, in particular printed circuit boards, by means of a suitable treatment fluid. The nozzle arrangement comprises a lower inlet box and a housing box, whereby the treatment fluid is conducted through the lower inlet box, through holes in the bottom of the housing box, into the interior of the housing box. The housing box has a central partition wall in combination with two perforation levels and slots arranged above these, as a result of which the treatment fluid flows to the two slots and two uniform sinusoidal surge profiles are formed above them, which flow through the workpieces, in particular the drillholes of printed circuit boards. An intensive exchange of material is thereby guaranteed due to the Venturi effect.

With the surge nozzle arrangements described above, the flow rate is greatest in an area connected to the inlet of the treatment fluid, since it is here that the greatest volume of treatment fluid emerges. As the distance from the connection area increases, so the flow rate decreases accordingly, since in each case a part

of the treatment fluid flows out via individual nozzle apertures of the surge nozzle arrangements. As a result of this, in addition to a static pressure an impact or total pressure and irregular flow rates are incurred at the nozzle apertures. A further consequence is differing outlet volumes of treatment fluid.

During the wet chemical treatment of very thin and/or sensitive treated material, there is also the risk that the treated material will be deflected out of the movement path or conveying path by the fluid surge incurred on one edge of the treated material, in an inlet area of the nozzle arrangement. This can lead to a situation in which the treated material scratches along the nozzle arrangement or completely gets caught, which leads to the wastage of the treated material or to a blockage inside the corresponding treatment system. In the event of a blockage, production must be interrupted in order for the blockage to be cleared, which in most cases leads to further wastage due to long treatment time in other treatment stations.

The present invention is therefore based on the object of providing a nozzle arrangement and a method for the treatment of a treated material, in particular for the treatment of very thin plate-shaped treated materials with a treatment fluid, which resolves the problem referred to heretofore, and in particular avoids the treated material from being deflected out of the conveying path in the inlet area of the nozzle arrangement by the flow of the treatment fluid or another treatment medium. This means that in the inlet area of the nozzle arrangement the forces perpendicular to the plane of the treated material must be as low as possible.

In accordance with the invention, this object is achieved by a nozzle arrangement with the features of the independent Claim 1 and by a method with the features of the independent Claim 27. The dependent claims define in each case preferred or advantageous embodiments of the invention.

The basic idea on which the method and nozzle arrangement in accordance with the invention are based consists of a delivery or a removal of a treatment medium

with a flow component in a conveying direction of a treated material. As a result, the treatment medium is drawn in in the surrounding area of an inlet area of the nozzle arrangement or a treatment channel, so that the conveying of the treated material in the treatment channel is supported.

The nozzle arrangement in accordance with the invention serves for the treatment of treated material, such as in the form of printed circuit boards or printed circuit films, as plates or endless material, with a treatment fluid or, more generally, a treatment medium, whereby the treated material can be conveyed in a conveying plane along the conveying direction from an inlet area to an outlet area of the nozzle arrangement. In addition to a treatment fluid, the treatment medium can also, for example, be a gaseous treatment medium. In this situation, the nozzle arrangement comprises at least one nozzle aperture, which is designed in such a way that a fluid flow of the treatment fluid or flow of treatment medium runs through the nozzle aperture at a predetermined angle obliquely in relation to the conveying plane of the treated material. The angle is predetermined in such a way that the fluid flow or flow of treatment medium is deflected into the conveying direction of the treated material or flows out of the nozzle aperture already moving in this direction.

The result of this is that the treatment fluid or treatment medium flows essentially from the at least one nozzle aperture in the direction of the outlet area of the nozzle arrangement, but not in the direction of the inlet area of the nozzle arrangement. As a result of this, a negative pressure occurs in a treatment channel of the nozzle arrangement, formed by the nozzle arrangement and the treated material, through which circulating treatment medium is drawn in in the inlet area of the nozzle arrangement, and the risk is avoided of the treated material being deflected out of the conveying plane or out of an intended conveying path.

The deflection of the fluid flow or flow of treatment medium is preferably effected by the at least one nozzle aperture being formed by at least one nozzle aperture

channel, which extends at an acute angle in relation to the conveying plane of the treated material. The angle in this situation preferably amounts to a maximum of 80°. However, an angle of between 0° and 60°, or even more preferably 10° and 30° has proved to be particularly advantageous.

The nozzle arrangement in accordance with the invention can be designed either for the spraying of the treatment medium onto the treated material or for sucking up the treatment medium. In the first case, i.e. if the at least one nozzle aperture is designed for the delivery of the treatment medium, the angle opens opposite to the conveying direction of the treated material, so that the flow of the treatment medium is deflected into the conveying direction of the treated material. In this case, it is particularly advantageous if the at least one nozzle aperture is arranged in a housing wall of the nozzle arrangement, extending essentially along the conveying plane, in such a way that a distance from the at least one nozzle aperture to the inlet area is smaller than the distance from the at least one nozzle aperture to the outlet area.

In the second case, i.e. if the at least one nozzle aperture is designed to receive or suck up the treatment medium, the angle opens in the conveying direction of the treated material, so that the situation is in turn attained that the flow of treatment medium is deflected into the conveying direction of the treated material. In this situation it is particularly advantageous if the at least one nozzle aperture is arranged in the housing wall extending essentially along the conveying plane, in such a way that a distance from the at least one nozzle aperture to the outlet area is smaller than the distance from the at least one nozzle aperture to the inlet area.

As a result of this asymmetrical configuration of the nozzle arrangement, it is guaranteed that an extended treatment channel is formed between the nozzle arrangement and the treated material, in which the treatment medium flows in the conveying direction of the treated material. This guarantees a more effective treatment of the treated material with the treatment medium. However, it is not mandatory for the nozzle aperture to be arranged in the vicinity of the inlet area or

the outlet area.

Preferably, the nozzle arrangement is designed in such a way that a distance between a housing wall of the nozzle arrangement, preferably that housing wall in which the at least one nozzle aperture is arranged, and the conveying plane decreases in the conveying direction of the treated material in a section between the inlet area and the at least one nozzle aperture. As a result, in this section a channel opening in wedge fashion in the direction of the inlet area is formed between the housing wall and the conveying plane. Preferably, the nozzle arrangement is also designed in such a way that a distance interval between the housing wall of the nozzle arrangement and the conveying plane increases in the conveying direction of the treated material, in a section between the at least one nozzle aperture and the outlet area so that in this section a channel opening in wedge fashion in the direction of the outlet area is formed between the housing wall and the conveying plane.

The wedge-shaped channels, which are preferably formed on both sides of the treated material, in particular the combination of the wedge-shaped channels referred to heretofore, create, by means of what is referred to as the Venturi effect, an additional negative pressure in the inlet area of the nozzle arrangement. Because the nozzle arrangement is preferably arranged in the treatment medium, treatment medium is simultaneously drawn in from the surrounding area of the inlet area. As a result of the treatment medium being drawn in, a cushion is formed therefrom in the inlet area towards the housing walls of the nozzle arrangement, so that any contact between the treated material and the housing walls of the nozzle arrangement is reliably avoided.

Preferably, front edges of the nozzle arrangement in the inlet area of the nozzle arrangement are bevelled or rounded, in order to prevent eddy formations which could deflect the treated material out of the path.

The at least one nozzle aperture is preferably designed in such a way that it

extends over a width in a width direction perpendicular to the conveying direction along the conveying plane. The width in this situation is selected as a function of a corresponding width of the treated material, so that a uniformly areal treatment of the treated material is guaranteed. The nozzle arrangement can in particular be designed as slot-shaped or as a row of apertures arranged next to one another with a distance interval in between, so that a uniform treatment is guaranteed over the entire width of the treated material. In this direction, the nozzle aperture is preferably arranged in parallel with the conveying plane.

Because of the desired inlet suction effect of the nozzle arrangement, if the fluid distribution is uneven over the width direction of the movement path the risk arises that the treated material will be pulled in to one side, and will therefore leave the conveying path on one side, or get caught at the side peripheries of the conveying path.

For better distribution of the treatment medium, it is therefore advantageous if the nozzle arrangement comprises a medium channel or fluid channel for transport of the treatment medium, extending along the at least one nozzle aperture. Preferably, the medium channel is connected to the at least one nozzle aperture by distribution apertures which are spaced from one another along the at least one nozzle aperture. The distribution apertures represent a flow resistance and therefore improve the distribution of the treatment medium over the entire width of the nozzle aperture. Preferably, the distribution apertures have the same diameter and the same length, but different distances. Other configurations are, however, also possible.

In accordance with one embodiment, the nozzle arrangement comprises an insertion element arranged in the medium channel, the displacement volume of which increases as the distance interval from a connection aperture increases, this aperture being provided for the introduction or removal of the treatment medium. As a result, it can be guaranteed that a passage cross-section of the medium channel, i.e. a cross-section surface area available for the passage of the

treatment medium, decreases as the distance from the connection aperture increases. The insertion element can in this situation be designed in such a way that the passage cross-section is reduced either continuously or in stages as the distance interval from the connection aperture increases. A continuous decrease in the passage cross-section can be achieved, for example, by a correspondingly shaped insert or a corresponding increase in a wall thickness of a housing of the medium channel. A stepped reduction in the passage cross-section can be attained, for example, by the insert being composed of individual sections or segments. These segments may be simple displacement bodies or perforated bodies, whereby, for example, the passage cross-section is determined by the dimensions of the hole. The individual segments can be assembled by adhesive bonding, welding, tensioning rods, or bracing. The stepped reduction of the passage cross-section can in this case be designed in particular in such a way that the stages are allocated to corresponding distribution apertures, whereby preferably the reduction in the passage cross-section at a particular stage is adapted to the flow of the treatment medium by means of the corresponding distribution aperture. The passage cross-section of the medium channel can therefore be adapted to the volume of the treatment medium flowing through the medium channel in a specific time unit, so that a uniform distribution of the flow rate and of the pressure is obtained. The staged composition of the insertion element from individual segments also offers the advantage of very low manufacturing costs.

In this connection it is also possible for the distribution apertures which connect the medium channel to the nozzle aperture to be provided with different lengths, i.e. as holes in a housing wall with a wall thickness of different stages. Likewise, if the at least one nozzle aperture comprises a large number of apertures arranged along the width direction, the design can be such that the individual apertures form channels or holes of different length. Due to the different length configuration of the distribution aperture or the apertures arranged next to one another of the at least one nozzle aperture, different flow resistance values are incurred, which contribute to a further evening-out of the flow rate. Equal hole diameters with

different distance intervals between holes are also possible.

The distribution apertures referred to heretofore may all have the same diameter. In the sense of adjusting the flow rate, however, it may also be advantageous to design the distribution apertures with different diameters. This means that the diameters of the distribution apertures can be adapted to the flow rates in the medium channel and the pressure ratios associated with this. In addition, with valve apertures with different diameters the ends of the distribution apertures can also be provided with countersinks, which in turn have the same diameter. As a result, a further equalisation of the flow rate and, in particular, of the flow rate at emergence from the distribution apertures, is effected.

The distribution apertures described heretofore can be created in the form of corresponding holes in the insertion element or in a housing wall. The insertion element can be designed in its longitudinal direction, i.e. along the direction of movement, with a U-shaped cross-section, so that a braced overall shape is produced, which can be held by clamping in a housing of the nozzle arrangement.

It is particularly advantageous if, in the case of a nozzle aperture with the shape of a slot, this is formed by the housing wall and an opposite insert strip. In this case, the insert strip can be removed for the cleaning of the nozzle arrangement, and the inherently narrow nozzle aperture can therefore be made easily accessible for cleaning tools.

In accordance with a preferred embodiment of the invention, the cross-section of the treatment channel can be adapted by appropriate shaping to the desired flow rate, parallel to the plane of the treated material. This is preferably effected by means of the insert strip, which is designed to be replaceable, such that the nozzle arrangement can be adapted with little effort to the requirements for a specific treated material.

By the shaping of the treatment channel it can also be attained that a negative

pressure is created in a defined area. This is likewise preferably effected by means of at least one replaceable insert strip. As a result of the negative pressure in a defined area it is possible to arrange for the treatment medium to be caused to flow into or through blind holes or passage holes of the treated material.

In accordance with the invention provision is therefore made for the cross-section of the treatment channel to be influenced in a specific manner, in order thereby to adjust the flow rate or to create a negative pressure in a defined area. This is preferably achieved by a narrowing of the treatment channel being induced at one or more positions along the conveying direction within the treatment channel.

In accordance with a preferred embodiment, the outlet cross-section of the slot-shaped nozzle aperture can be adjusted by means of a nozzle rail. The nozzle rail, which is made, for example, of metal or plastic, can for this purpose be located in an adjustable manner at the housing of the nozzle arrangement. It is particularly preferable for the nozzle rail to be designed in a replaceable manner, in order for different geometries of the nozzle aperture to be selected. In this way the nozzle arrangement can be adapted in a precise and flexible manner to different process requirements and different types of treated material.

Preferably, if the at least one nozzle aperture is formed by at least one nozzle aperture channel, which extends at an acute angle in relation to the conveying plane of the treated material or approximately parallel to it, then the distribution apertures are also formed by distribution channels or distribution holes, which are arranged at an angle in relation to the conveying plane of the treated material, which is greater than the angle of the nozzle aperture channels in relation to the conveying plane. In addition to this, the distribution apertures or distribution channels or distribution holes can be arranged offset in the conveying direction in relation to the at least one nozzle aperture. As a result of these measures, a multiple deflection of the flow of the treatment medium takes place. In particular, as a result of this the risk can be avoided that, because of dynamic forces in the flow of the treatment medium, at higher flow rates this medium does not emerge

at the nozzle apertures in the direction of the nozzle aperture channel.

The nozzle arrangement in accordance with the invention can be designed as an individual nozzle arrangement with a nozzle aperture on one side of the treated material or as a nozzle arrangement on both sides, with one nozzle aperture in each case below and above the treated material.

It is particularly advantageous if the nozzle arrangement comprises at least one further nozzle aperture, which is arranged on a side of the conveying plane of the treated material located opposite the at least one nozzle aperture. As a result of this, the treated material can be treated from both sides when running through the nozzle arrangement, i.e. from above and below. This is advantageous in particular with treated material which requires treatment on both sides, such as printed circuit boards or films printed on both sides. In particular, treatment steps can be saved by doing this, and the overall treatment time shortened, with the result that overall less effort and expenditure is incurred. In this situation it is particularly advantageous for the nozzle arrangement to be designed to be mirror-symmetrical in relation to the movement plane of the treated material, so that the advantages of the nozzle arrangement described heretofore can be provided on both sides of the treated material.

For treating blind holes or passage holes in the treated material, it is further advantageous for at least one or more additional nozzle apertures to be provided for, which deliver the treatment medium essentially perpendicular to the surface of the treated material. These additional nozzle apertures can be arranged upstream or downstream in relation to the nozzle apertures described heretofore, which have the effect of a flow component in the conveying direction. In the event of nozzle apertures being provided for on both sides of the plane of the treated material, the additional nozzle apertures which are arranged on different sides of the treated material can be directly opposite of one another or offset in relation to one another. The additional nozzle apertures can be supplied with the treatment medium in an adjustable or non-adjustable manner. This can be done via the

same medium channel, which is used to supply the nozzle apertures with flow components in the direction of movement referred to heretofore. To particular advantage, passage holes in the treated material are treated by mans of the additional nozzle apertures, since a positive pressure pertains at the additional nozzle aperture, while, for example, a negative pressure is present in the treatment channel on the side opposite the treated material. As an alternative, a separate supply can also be provided for. In the latter case, a separate delivery device or pump can also be provided for delivering the treatment medium.

It has further been shown that the conveying of the treated material through the treatment channel of the nozzle arrangement can be improved by specifically reducing the flow component in the conveying direction or perpendicular to the plane of the treated material in the outlet area of the nozzle arrangement. This is preferably achieved, in addition to the measures described heretofore, by the cross-section of the treatment channel being widened in the outlet area of the nozzle arrangement. Accordingly, by shaping the nozzle arrangement or the treatment channel, the result can be achieved that the flow rate of the treatment medium on the side of the inlet area continuously increases along the direction of movement, while on the side of the outlet area the flow rate continuously decreases. In addition to this, the outlet area can be provided with flow-influencing elements. As flow-influencing elements, projections, baffle plates, or webs, formed in or on the surface of the nozzle arrangement, have proved to be advantageous. Thanks to such flow-influencing elements, flow eddies are avoided, and therefore the flow components perpendicular to the plane of the treated material and in the movement direction are minimised. The flow-influencing elements can, in addition, guarantee an additional guide function for the treated material.

The present invention, which makes provision for a flow of the treatment medium to be specifically induced in the direction of movement of the treated material in order thereby to draw in the treatment medium from the inlet area of the nozzle arrangement, in this way effectively supports the movement of the treated material

through the treatment channel of the nozzle arrangement. It is even possible in this way, for example with very thin treated material which is available as what is referred to as "endless" material, for conveying to be achieved without further drive means, for example rollers, wheels, clamps, or the like. In addition to this, the drawing in of treatment medium from the surrounding area of the inlet area guarantees an effective circulation of the treatment medium. The volume flow which is achieved by this drawing in of the treatment medium in the inlet area is substantially greater than that which is produced by the nozzle apertures alone. In addition, the nozzle arrangement in accordance with the invention allows for a contact-free conveying of the treated material.

The nozzle arrangement is particularly well-suited for use with the wet-chemical treatment of printed circuit boards or printed circuit films as treatment material, as part of a corresponding device or system. The nozzle arrangement offers the advantage that, because of the specially designed flow conditions, the treated material is not deflected out of its intended conveying path. This applies in particular in the inlet area of the nozzle arrangement. The nozzle arrangement further makes possible a uniform flow rate and flow volume of the treatment medium along the width of the nozzle arrangement, as a result of which a more uniform treatment result is achieved. In addition, a uniform jet or surge geometry is provided, and, in particular, a uniform alignment of the flow of the treatment medium to the nozzle apertures. Last but not least, the nozzle arrangement allows for great compactness and manufacture from a small number of components, as a result of which the spatial requirement in corresponding devices or systems and manufacturing costs will be kept low.

The present invention is described in greater detail hereinafter by reference to the appended drawings, on the basis of preferred embodiments.

Fig. 1A shows a side view of an embodiment of a nozzle arrangement in accordance with the invention, with two nozzles in a partial cross-section along a section line C-C' represented in Fig. 2;

Fig. 1B shows an enlarged section of one of the nozzles represented in Fig. 1A;

Fig. 2 shows a sectional view of the embodiment from Fig. 1A in a partial cross-section along a sectional line A-A' represented in Fig. 1A;

Fig. 3 shows a sectional view of the embodiment from Fig. 1A in a partial cross-section along a sectional line B-B' represented in Fig. 1A;

Fig. 4 shows a sectional view of a further embodiment of the nozzle arrangement in accordance with the invention along a sectional line C-C' represented in Fig. 5;

Fig. 5 shows a sectional view of the embodiment from Fig. 4 in a partial cross-section along a sectional line B-B' represented in Fig. 4;

Fig. 6 shows a sectional view of the embodiment from Fig. 4 in a partial cross-section along a sectional line A-A' represented in Fig. 4;

Fig. 7 shows a sectional view of a further embodiment of the nozzle arrangement in accordance with the invention with an adjustable nozzle rail;

Fig. 8 shows a further embodiment of the nozzle arrangement in accordance with the invention with additional nozzle apertures, and

Fig. 9 shows a further embodiment of the nozzle arrangement in accordance with the invention whereby parts of the nozzle arrangement which are arranged on both sides of a conveying plane are of different designs.

Fig. 1A shows a nozzle arrangement in accordance with an embodiment of the present invention, which is suitable in particular as a surge nozzle for galvanizing systems with a horizontal run-through for printed circuit boards or printed circuit films. The nozzle arrangement comprises two nozzles which extend along a

conveying plane, in which a treated material is moved along a conveying path from an inlet area 15 to an outlet area 16. The two nozzles are arranged directly opposite to each other and mirror-symmetrically to the conveying plane. Located between the two nozzles is a treatment channel, through which the treated material can be passed.

The nozzles comprise in each case a housing 2, in which a nozzle aperture 8 is provided for in the side facing the conveying plane. A treatment medium in the form of a treatment fluid for the treatment of the treated material is supplied to the nozzle through a connection aperture 1, which is arranged on a face side of the nozzles. From the connection aperture 1 the treatment fluid passes into a medium channel in the form of a fluid channel 6, which is connected to the nozzle aperture by distribution apertures 7. A fluid flow of the treatment fluid is indicated in Fig. 1 by the arrows 11 and 11'.

The housing 2 of the nozzles comprises in each case a side wall on one side of the inlet area 15 and a side wall on one side of the outlet area 16 of the nozzle arrangement. The housing 2 of the nozzles is closed off by a housing cover 13, so that the housing 2 together with the housing cover 13 encloses the fluid channel 6. Arranged in the fluid channel 6 is an insertion element 3 with a U-shaped cross-section. The open side of the insertion element 3 is in this case arranged on one side of the nozzle aperture 8 in the housing 2 in such a way that the distribution apertures 7 are freely accessible from the fluid channel 6. The insertion element is preferably made of plastic, and is provided on its outside with a bracing element 4, likewise U-shaped, for stabilizing the nozzle and the housing 2. The U-shaped bracing element 4 preferably consists of a metal which is resistant to the chemicals being used, such as, for example, stainless steel, titanium, niobium, or the like.

The treated material 10 runs through the nozzle arrangement in the horizontal conveying plane in a conveying direction designated by the arrow 18. In this situation the treated fluid is conducted from the nozzle apertures 8 obliquely onto

the treated material 10. As a result, a suction effect is exerted on the side of the inlet area 15 of the nozzle arrangement. The nozzle arrangement is arranged in a fluid medium, which may be, for example, the treatment fluid, with the result that, due to the suction effect, additional fluid, such as indicated by the arrow 11', is drawn in into the treatment channel.

Fig. 1B shows an enlarged partial view of one of the nozzles from Fig. 1A. In this it can be seen in particular that the nozzle aperture 8 is formed by a nozzle aperture channel, which forms an acute angle 17 in relation to the conveying plane of the treated material 10. The angle 17 opens against the conveying direction 18, so that the treatment fluid is deflected into the conveying direction 18 by the nozzle aperture channel. The distribution apertures 7 are in each case formed by a distribution channel in the form of holes in the housing 2, this channel being arranged at an angle in relation to the conveying plane, this angle being greater than the angle 17 of the nozzle aperture channel. The fluid flow is therefore, as indicated by the arrow 11, deflected several times into the conveying direction 18 of the treated material 10.

Fig. 2 shows a sectional view of the nozzle arrangement of Fig. 1A and Fig. 1B in the form of a partial cross-section along a sectional line A-A', represented in Fig. 1A, i.e. along a width direction of the nozzle arrangement. As can be seen from Fig. 2, the connection aperture 1 is designed in the form of a connection nozzle with a sealing ring 14, through which the treatment fluid enters the fluid channel 6. In particular, it can be seen that the insertion element 3 is designed with a wedge shape, so that a passage cross-section of the fluid channel decreases as its distance from the connection aperture 1 increases. It can further be seen that the distribution apertures 7 are formed as holes in a wall of the housing 2 arranged equidistant from one another. The thickness of this wall is essentially constant along the width of the nozzle, so that an essentially equal length of the distribution holes 7 is attained.

As can be seen from Fig. 2, the nozzle aperture 8 is designed as a slot extending

along the direction of width of the nozzle.

Fig. 3 shows a sectional view of the nozzle arrangement from Fig. 1A, Fig. 1B, and Fig. 2 in the form of a partial cross-section along a sectional line B-B' represented in Fig. 1A. As can be seen from Fig. 3, the distribution apertures 7 are holes with circular cross-section arranged equidistant from one another. In particular, the distribution apertures 7 are arranged in a row next to one another, which is located at a side of the nozzle turned towards the inlet area 15.

The fluid flow indicated in Figs. 1A and 1B by the arrows 11 therefore leads from the wedge-shaped flow channel 6 through the distribution apertures 7, in the form of distribution holes with circular cross-section, through the nozzle aperture 8 designed as a uniformly broad slot and onto the treated material 10. Between the distribution holes and the nozzle aperture 8 the fluid flow is transformed into a flat jet, which extends essentially over the entire width of the treated material.

As a result of the wedge-shaped insertion element 3, it is guaranteed that the flow rate is equally great at all points of the fluid channel 6. Because all the distribution apertures 7 have the same dimensions, a very uniform spray image is obtained, i.e. a uniform jet or surge geometry, as well as a uniform direction of the fluid flow.

The uniform geometry of the fluid flow is of particular significance for the production of a suction effect due to what is referred to as the Venturi effect, because, with a non-uniform suction along the width direction, the treated material is drawn in obliquely, and in that situation can get caught at a side periphery of the conveying path.

To avoid this, the nozzles and nozzle arrangement in accordance with the embodiment represented have the following features:

A) The nozzle aperture 8 is not arranged centrally, but at a lateral longitudinal edge of the nozzle in the vicinity of the inlet area 15.

B) The nozzle aperture 8 is designed in the form of a nozzle aperture channel, which, as represented in Fig. 1B, is arranged at an acute angle 17 in relation to the conveying plane of the treated material 10.

C) The thickness of the housing wall facing the conveying plane decreases in a section between the nozzle aperture 8 and the outlet area 16, with the result that the treatment channel broadens in wedge shape in the conveying direction 18 in this section.

D) Edges of the nozzle in the inlet area 15 and outlet area 16 are rounded, in order to avoid eddy formations in the treatment fluid.

E) In a section between the inlet area 15 and the nozzle aperture 8 the thickness of the housing wall facing the conveying plane increases, with the result that the treatment channel narrows in this area in wedge shape in the conveying direction 18 in this section.

This means in particular that both the inlet area and the outlet area, with the mirror-symmetrical nozzle arrangement shown in Fig. 1A, present a funnel shape.

As a result of this special shape of the nozzle geometry turned towards the treated material, a negative pressure is created in the inlet area 15 of the nozzle arrangement, which causes drawing in of fluid and treated material from the surrounding area of the nozzle arrangement into the treatment channel, as indicated by the arrows 11' in Fig. 1A. As a result in particular of the wedge shape or funnel shape of the treatment channel in the inlet area 15, the flow rate towards the nozzle aperture 8 is increased. As a result of the flow and the rounded edges of the nozzle, it is ensured that thin treated material in particular does not impact against the side walls of the nozzles. Due to the suction effect of the nozzle arrangement in the inlet area 15, more treatment fluid is drawn through the treatment channel than flows out through the nozzle apertures 8. This not only

prevents damage to the treated material but also speeds up the treatment, as a result of which shorter treatment times can be achieved than with conventional nozzle arrangements. For example it can be attained by means of the negative pressure that air which is present in blind holes or gas which is formed by the treatment is sucked out, and the wetting of the surface with treatment fluid is therefore improved.

In the outlet area of the nozzle arrangement, the flow rate decreases as the width of the treatment channel increases.

Both on the inlet area 15 side as well as on the outlet area 16 side, conveyor rollers can be arranged next to the nozzle arrangement. The conveyor rollers guarantee reliable movement of the treated material from or to adjacent treatment stations.

Fig. 4 shows a sectional view of a nozzle arrangement in accordance with a further and particularly preferred embodiment of the present invention. Fig. 4 is a partial cross-section along a line designated as C-C' in Fig. 5. Similar features and components of the nozzle arrangement in the embodiment shown in Figs. 1-3 are designated with the same reference numbers, and no further explanation is provided for them hereinafter.

As a departure from the embodiment described on the basis of Figs. 1-3, the nozzle arrangement from Fig. 4 has in the treatment channel 6 an insertion element 3a arranged on the side of the nozzle aperture 8. First distribution holes 9 are provided in the insertion element 3a, through which the treatment fluid is conducted from the fluid channel 6 into a deflection channel 5. The deflection channel 5 is formed by a corresponding deepening of the insertion element 3a. From there the treatment fluid passes through second distribution apertures 7, which correspond essentially to the distribution apertures of the embodiment from Figs. 1-3, to the nozzle apertures 8. The first distribution apertures 9 are arranged offset to the second distribution apertures 7 and the nozzle aperture 8 in the

conveying direction 18. As a result of this, a first deflection of the fluid flow through about 90° is incurred from the first distribution aperture 9 into the deflection channel 5, and a second deflection through about 90° from the deflection channel 5 into the second distribution aperture 7. A third deflection takes place, when the treatment fluid is conducted from the second distribution aperture 7 into the nozzle aperture channel. As a result of this, the desired direction of the fluid flow oblique to the conveying plane of the treated material 10 is guaranteed even at higher flow rates of the treatment fluid.

With the nozzle arrangement shown in Fig. 4, a surface of the nozzle facing the treated material 10 is formed by an insert strip 12. The insert strip 12 has a dovetail-shaped guide, which is inserted into the housing 2 of the nozzle which on this side is likewise designed in a dovetail shape. The nozzle aperture 8 is formed on one side by an edge of the insert strip 12, and on the other side by an opposite edge of the housing 2, so that in turn a slot-shaped nozzle aperture 8 is produced arranged along the width of the nozzle. The side of the insertion element facing the conveying plane of the treated material 10 has essentially the same shape as has been described heretofore for the corresponding housing wall of the nozzle arrangement from Figs. 1-3. As a result of this, it is guaranteed that the same advantageous flow effects will be achieved.

To clean the nozzle, the insertion element 12 can be removed, so that the second distribution apertures 7 are freely accessible.

Fig. 5 shows a side view of the nozzle arrangement from Fig. 4 in the form of a partial cross-section along a sectional line B-B' represented in Fig. 4. From Fig. 5 it can be seen in particular that the first distribution apertures 9 in the insertion element 3a are arranged equidistant from each other along the width direction of the nozzle arrangement. Due to the wedge shape of the insertion element 3a, different lengths of the distribution holes result in each case for the individual first distribution apertures 9. The wedge shape of the insertion element 3a is in this case designed in such a way that the passage cross-section of the fluid channel 6

is reduced as the distance from the connection aperture 1 increases. This means that the distribution holes become longer the further they are spaced apart from the connection aperture 1, as a result of which a greater pressure drop is likewise incurred over the distribution holes. This has an equalizing effect in particular towards the end of the fluid channel 8 opposite the connection aperture 1. In addition, the wedge shape of the insertion element 3a is designed in such a way that the remaining height of the fluid channel at this end is not zero, but has a final value of, preferably, 2-8 mm at this point furthest distant from the connection aperture 1.

Fig. 6 shows a side view of the nozzle arrangement from Figs. 4 and 5 in the form of a partial cross-section along a sectional line A-A' represented in Fig. 4. From Fig. 6 it can be seen that the first distribution apertures 9 are arranged in relation to the conveying direction 18 along a row formed centrally in the nozzle. The second distribution apertures 7 are, however, as already explained on the basis of the embodiment from Figs. 1-3, arranged offset in the direction of the inlet area. As a result, the advantageous multiple deflection of the fluid flow is produced, as already mentioned. The first and second distribution apertures 7, 9 are, as can be seen from Fig. 6, distribution holes with circular cross-sections. In this embodiment, the first and second distribution apertures 7, 9 have the same diameters. It may also be advantageous for the second distribution apertures 7 to be designed with a diameter which differs from the diameter of the first distribution apertures 9. It may also be advantageous if the first distribution apertures 9 and the second distribution apertures 7 have in each case diameters which differ from one another or different distance intervals.

With the latter embodiment of the nozzle arrangement, very good results were achieved in a number of tests with conductive films of different thicknesses. It has been shown in this situation that, as soon as the printed-circuit films were taken up by the suction, the conveying speed of the conductive films was substantially increased by the negative pressure. Despite the high conveying speed, no damage was incurred on the printed-circuit films. With the additional use of

conveyor rollers, it has been observed that even bent printed circuit films were stretched by the suction effect into the nozzle device, and ran through the nozzle arrangement on a predetermined conveying path without any damage or jamming.

It should be noted at this point that with the realisation of only a part of the measures described heretofore or of the features of the nozzle arrangement, it is already possible for an adequate uniform supply of treatment fluid and suction effect to be achieved for the particular application, such that the treated material can be guided reliably through the nozzle arrangement during the chemical treatment.

A range of modifications to the embodiments represented in the figures are of course also conceivable, without departing from the basic conception of the present invention.

Thus, for example, the connection aperture 1 can be arranged in the centre of the housing 2 in relation to the width direction of the nozzle arrangement, so that the supply of the treatment fluid takes place in the centre. In this variant, the passage cross-section of the fluid channel 6 in the interior of the housing 2 would then decrease starting from the middle connection aperture 1 towards the two ends of the nozzle arrangement, i.e. on both sides, and the thickness of the insertion element 3 or 3a respectively would increase starting from the middle connection aperture 1 towards the two ends, so that the length of the distribution holes 9 in the insertion element 3a increases on both sides.

In addition to this, in the embodiments shown, the continually reducing passage cross-section of the fluid channel 6 is realised by the increasing alone the respective height of the insertion element 3 or 3a. It is of course also conceivable that several side walls of the fluid channel 6 have an increasing wall thickness in the width direction of the nozzle. In addition to this, with lesser demands, the deflection channel 5 for further pressure distribution can be omitted.

In order to improve the uniformity of the flow rate, the slot-shaped nozzle apertures 8 can also be provided with a variable width, whereby the width can decrease in particular in a width direction of the nozzle, starting from the connection aperture 1.

As already mentioned, the distribution apertures 7 or 9 can also be designed with different diameters, whereby, in particular for the realisation of a continuously increasing flow resistance, a corresponding decrease of the diameters of the distribution apertures 7 or 9 is conceivable.

At the side of the distribution apertures 7 or 9 respectively, which delimit the fluid channel 6, the apertures may also be provided with countersinks having a larger diameter. In order to obtain a flow resistance which increases continuously in the width direction of the nozzle, these countersinks can be provided with different depths, in particular with a depth which increases continuously in the width direction of the nozzle.

It is additionally also possible for the distance interval between the distribution apertures to be varied in such a way that the distribution apertures close to the connection aperture 1 have a smaller distance interval than those which are further away from the connection aperture 1.

It is also possible to omit the bracing 4 represented in the figures if, for example, instead of this, a thicker housing wall is used. It is likewise conceivable for the insertion element 3 or 3a respectively and the housing 2 to be designed as one piece. Finally, reference should be made to the fact that, in the embodiments shown, it is indeed the case that only one slot-shaped nozzle aperture 8 is provided to extend in the width direction of the nozzle, but several slots, arranged in the width direction of the nozzle, can also be used, arranged for example at uniform distance intervals from one another. If appropriate, round apertures arranged next to one another can also be used.

It is also possible for the treatment channel running in a wedge shape to be established between a nozzle and the treated material 10, or the funnel-shaped course of the treatment channel respectively to be created between the two nozzles by means of an oblique arrangement of the nozzles and a corresponding adaptation of the respective opposite surface. In particular, in this situation asymmetric arrangements of upper and lower nozzles may also be advantageous.

Fig. 7 shows a further embodiment of the nozzle arrangement in accordance with the invention, which basically corresponds to that which was described on the basis of Fig. 1A. Similar components are designated with the same reference numbers. As a departure from Fig. 1A, however, the nozzle aperture 8 is designed in an adjustable manner. The distribution apertures 7 extend obliquely in relation to the conveying direction 18 from the fluid channel 6 in the direction of the inlet area 15 of the nozzle arrangement. The distribution apertures 7 have a distance interval which varies along the width direction of the nozzle arrangement, the width becoming greater the further away they are from the connection aperture 1.

A nozzle rail 20 is arranged in an adjustable manner at a front housing wall of the housing 2. The nozzle rail 20 extends along the front housing wall initially in a direction perpendicular to the plane of movement of the treated material 10, in order then to transition into a front edge area, which turns into the conveying direction. An inner surface of the front edge area of the nozzle rail 20 faces the distribution aperture 7, while an outer surface of the front edge area forms a front edge of the inlet area 15 of the nozzle arrangement and faces the treated material 10. The nozzle aperture 8 is therefore delimited by the nozzle rail 20 and a housing wall.

The nozzle rail 20 is attached in an adjustable manner to the housing wall. In particular, the nozzle rail 20 can be displaced by means of a setting screw 21 in a direction perpendicular to the conveying plane. The adjustable arrangement can, for example, be guaranteed by a longitudinal hole in the nozzle rail 20, through

which the setting screw 21 is introduced. In this way, the nozzle rail 20 can be secured in a new position by releasing the setting screw 21, displacing the nozzle rail 20, and by subsequent tightening of the setting screw 21, as a result of which, on the one hand, the cross-section of the nozzle aperture 8 is changed and, on the other, the distance between the outer surface of the front edge area and the conveying plane of the treated material 10 is changed. Accordingly, by means of the nozzle rail 20, both the cross-section of the nozzle aperture 8 as well as the cross-section of the treatment channel in the inlet area 15 can be adjusted. Other embodiments of the adjustable attachment of the nozzle rail 20 are of course also conceivable. For example, the housing wall at which the nozzle rail 20 is located can extend obliquely in relation to the conveying plane.

In addition to this, the nozzle rail 20 can also be shaped in different ways. This relates to the front edge area in particular, which turns in the conveying direction 18 of the treated material 10. Accordingly, different curvatures can be provided for the front edge area. With an oblique arrangement of the nozzle rail 20 a basically non-curved shape of the nozzle rail 20 is also conceivable.

Preferably, different types of nozzle rails 20 are provided for different types of treated material and for different process requirements, which can be fitted in a replaceable manner on the housing 2 of the nozzle arrangement. In this way, the precision and flexibility of adjustment of the nozzle arrangement to the individual requirements is increased.

As in Fig. 1A, the nozzle arrangement is arranged on both sides in relation to the conveying plane of the treated material. In particular, this means that one nozzle is arranged above the conveying plane and one nozzle is arranged beneath the conveying plane. It is of course also possible, however, for the nozzle arrangement to comprise only one nozzle, which is arranged on one side of the treated material, according to Fig. 1B. In addition to this, the nozzle arrangement represented in Fig. 7 can also be provided with an insert strip, as was described on the basis of Fig. 4. In this case, the nozzle aperture 8 is delimited by the edge

of the nozzle rail 20 and by the insert strip 12.

If the nozzle arrangement is arranged at only one side of the conveying plane, the treated material can be additionally supported on the opposite side, for example by means of rollers, wheels, or guide rails. The negative pressure on the one side of the treated material leads to a good flushing through of even the smallest passage holes in the treated material.

Fig. 8 shows a nozzle arrangement in accordance with a further embodiment of the invention. Components which correspond to those of Figs. 1-7 are designated by the same reference numbers. The nozzle arrangement represented in Fig. 8 corresponds to that which was described on the basis of Fig. 7, whereby, however, the nozzles in each case have an additional nozzle aperture 22, which is designed so as to emit the treatment fluid in a direction essentially perpendicular to the conveying plane of the treated material 10. The additional nozzle apertures 22 cause the flow of the treatment fluid to be intensified through holes in the treated material, such as passage holes or blind holes. In this way, a more effective treatment of the treated material 10 is achieved in the area of the holes formed in it.

In Fig. 8 the additional nozzle apertures 22 are arranged in the upper nozzle and in the lower nozzle opposite one another. This configuration can be advantageous, for example, for the treatment of blind holes. As an alternative, however, it is also possible for the additional nozzle apertures 22 to be arranged offset in relation to one another, which is particularly advantageous if a continuous flow is intended to be created through passage holes in the treated material 10.

With the nozzle arrangement shown in Fig. 8, the treatment fluid is supplied to the additional nozzle aperture 22 via the fluid channel 6, which also serves to supply the treatment fluid to the nozzle aperture 8. As an alternative it is possible to provide for a separate delivery of the treatment fluid to the additional nozzle aperture 22. For this purpose, the fluid channel 6 can, for example, be divided

into two separate channels by means of a partition wall, not shown here. In addition to this, means can also be provided in order for the flow of treatment fluid through the additional nozzle apertures 22 to be adjusted or controlled independently of the flow of treatment fluid through the nozzle aperture 8. With a separate delivery of the treatment fluid to the additional nozzle aperture 22, it is also possible, in particular, for a separate delivery device or delivery pump to be provided for.

The nozzle arrangement represented in Fig. 8 has a symmetrical configuration, with nozzles above and below the conveying plane of the treated material 10, whereby these nozzles are designed to be mirror symmetrical in relation to the conveying plane. As has already been mentioned, however, it is not mandatorily required for the nozzle arrangement to be designed symmetrically in relation to the conveying plane. This is the case, for example, with the embodiment which is represented in Fig. 9.

Fig. 9 shows a nozzle arrangement which consists of two nozzles, which are arranged on both sides in relation to the conveying plane of the treated material 10 and which have different configurations. Components which correspond to those of Figs. 1-8 are again provided with the same reference numbers. The nozzle which is arranged beneath the conveying plane corresponds in its configuration to that which is represented in Fig. 7. Arranged above the conveying plane of the treated material 10, however, is a nozzle with a different configuration. This differs from the nozzle arranged below the conveying plane in particular in that it is equipped with only one nozzle aperture 23, which emits the treatment fluid essentially perpendicular to the conveying plane of the treated material 10. As a result, on the side of the conveying plane with the treatment fluid emerging approximately perpendicular, a negative pressure is created. In particular with thin treated material, additional guide elements or support wheels can be located at the side of the conveying plane with negative pressure, which are not shown in the figures. The conveying of the treated material 10 is therefore supported in an effective manner, while the nozzle which is arranged above the conveying plane is

flexible in respect of the design of its nozzle aperture 23 and can be adjusted to suit special requirements in the treatment of the surface of the treated material 10 facing it. Overall, therefore, a high degree of flexibility pertains with regard to the design of the nozzle arrangement in accordance with the invention.

It is possible, in addition, for the inlet area or the outlet area of the nozzle arrangements presented in Fig. 1-9 to be provided with guide elements, which serve on the one hand to reduce or avoid turbulence in the treatment fluid and, on the other, can also provide a guide function for the treated material 10. The guide elements can, for example, be designed in the form of webs or projections on the surface of the nozzle housing facing the treated material 10. These webs can be aligned parallel to the direction of movement 18, but may also deviate from this in order to guarantee a suitable guidance of the flow of the treatment fluid. In particular in the outlet area 16, where the treatment channel typically widens out, it can be advantageous for the guide elements to be designed in such a way that they define a conveying channel, the cross-section of which is less than that of the treatment channel. Accordingly, the movement of the treated material is restricted to a comparatively small area perpendicular to the conveying plane, while additional space is provided for the flow of the treatment fluid between guide elements. Thanks to the provision of the guide elements, it is possible in particular for an improved guidance of the treated material 10 to be achieved in the outlet area 16 of the nozzle arrangement. The guide elements may also comprise wheels or rollers.

It is also possible for the guide elements to be combined with rollers or wheels, whereby the guide elements can be designed in comb fashion, and wheels arranged between the webs of the comb-shaped structure. It is also possible, further, for wheels or a roller provided with indentations to project at the end of such a comb-shaped structure between its webs. These measures are well-suited to improving the guidance of the treated material 10 in the inlet area 15 and in particular in the outlet area 16. This is advantageous in particular if the treated material 10 is a thin film-type material, which is easily deflected out of its

conveying plane.

The nozzle arrangements described on the basis of Fig. 1-9 relate in all cases to a delivery of the treatment fluid from the nozzle arrangement onto the treated material 10. The nozzle arrangement, however, functions in a similar manner for the removal by suction of the treatment fluid from the treated material 10 into the nozzle arrangement, if the conveying direction of the treated material 10 or the arrangement of the nozzles is reversed. This can be advantageous in particular if, during the treatment, products of decomposition arise or solids are carried off. With the suction of the treatment fluid into the nozzle arrangement, the products of decomposition or solids are carried along, and so pass in the fastest way, for example, to a regeneration unit or to a filter, which removes the solids. Any impairment of the treatment result due to these substances is therefore almost entirely excluded.

Moreover, even if the embodiments described heretofore relate to nozzles or nozzle arrangements for the treatment of the treatment material with a treatment fluid, the invention is not restricted to this. Rather, the nozzle arrangement in accordance with the invention is also well-suited for gaseous treatment media or mixtures of fluid and gaseous treatment media. Thus, for example, hot air can be used for drying flexible thin treated material, or a water-air mixture as a treatment medium for moistening (as protection against the formation of flecks or spots). In addition to this, the nozzle arrangement in accordance with the invention is also well-suited for treatment with other gases which exert a chemical effect on the surface of the treated material, due to the uniform distribution of the treatment medium.

With the nozzle arrangements represented, the conveying of the treatment medium can be effected not only horizontally but also vertically. In that case, in order to achieve a uniform administration of flow, attention must be paid, with regard to the flow distribution through the distribution apertures and the adjustable nozzle rails, to the geodetic pressure differences at the vertically-positioned nozzle.

Use is therefore also possible with traditional "vertical systems", where the plates are lowered into different treatment tanks individually or mounted next to one another in racks. In this situation, the suction effect in the inlet area can be of use, as well as the other advantages of the nozzle.

In the case of a gaseous treatment medium, it is advantageous for the nozzle arrangement to be arranged in a gaseous medium, e.g. the gaseous treatment medium.

It is of course also possible for the nozzle arrangements described heretofore on the basis of Figs. 1-9 to be combined with one another. In particular, several nozzle arrangements can be arranged in series along the conveying path of the treated material. These nozzle arrangements preferably define complementary treatment zones.

For example, a treatment zone can be designed for suction removal of dirt particles into the nozzle apertures on one side or on both sides. A further treatment zone can be designed for the suction removal of gas from blind holes on one side or on both sides by flow-induced negative pressure. Another further treatment zone can be designed for flushing the passage holes, in that, as explained heretofore, on one side of the treated material a positive pressure is created, and a negative pressure on the other side of the treated material.

It is of course also possible for several treatment zones to be formed in one nozzle arrangement.

It is also preferential for the flow of the treatment medium, i.e. the quantity of the treatment medium which is delivered per time unit to a nozzle aperture or to the nozzle arrangement, and the pressure of the treatment medium, to be controlled or adjusted as a function of the properties of the treated material. In this situation, in particular the thickness of the treated material, the presence of blind holes or passage holes, and the degree of dirt contamination can all be taken into account.

In this situation it is also possible for the flow and/or pressure of the treatment medium of several nozzle rows inside the nozzle arrangement to be controlled or adjusted separately in such a way that a lateral deflection of the treated material from the conveying path will be prevented.

LIST OF REFERENCE SIGNS

| | |
|---|---|
| 1 | connection aperture |
| 2 | housing |
| 3,3a | insertion element |
| 4 | bracing |
| 5 | deflection channel |
| 6 | fluid channel |
| 7 | distribution aperture |
| 8 | nozzle aperture |
| 9 | distribution aperture |
| 10 | treated material |
| 11,11' | fluid path |
| 12 | insertion strip |
| 13 | housing cover |
| 14 | sealing ring |
| 15 | inlet area |
| 16 | outlet area |
| 17 | angle |
| 18 | conveying direction |
| 19 | fluid path |
| 20 | nozzle rail |
| 21 | setting screw |
| 22,23 | additional nozzle aperture |